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CONSERVATION ACCELERATION THROUGH SUCCESSIVE APPROXIMATIONS

by

© LeROY D. TRAVIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Conservation Acceleration Through Successive Approximations" submitted by LeRoy D. Travis in partial fulfilment of the requirements for the degree of Master of Education.

ABSTRACT

The primary purpose of the present study was to examine the possible role of selective reinforcement on successive approximations in the acquisition of stable and generalized conservation responses. Specifically, the present study tested the hypothesis that training incorporating the selective reinforcement of specific responses to a series of succeedingly greater deformations would produce a response that is (a) consistently emitted where and when appropriate, (b) generalized to any situation in which there is a deformation of any magnitude, and (c) impervious to extinction.

An attempt was made to accelerate the acquisition of the conservation of substance with 33 Ss ranging in age from 56 to 76 months, by embodying Skinnerian learning principles in the training procedure.

The results generally support the hypothesis although one major exception was found. That exception was that if Ss are trained on successive approximation the schedule of reinforcement utilized does not appear to have a significant bearing on extinction. More specifically, 20 out of 22 Ss acquired the conservation operation despite the fact that 11 Ss were reinforced according to a continuous schedule only.

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CHAPTER I

INTRODUCTION

A child is said to possess a conservation of substance operation if, on each occasion he is presented with a transformation of the shape of an object, he maintains that the quantity or amount of substance in that object remains invariant. Such a child insists that, despite their changes of shape, the objects remain unchanged in amount. Furthermore he can explain why (Côté, 1968; Mermelstein et al, 1967).

Jean Piaget (1965) has asserted that possessors of this, and the other conservation operations are more capable of behaving intelligently, that is adapt more readily, to the exigencies in their environments, than persons who do not possess the conservation operations. At the same time Piaget has maintained that specific training or teaching plays little or no role in the acquisition of the conservations. Nevertheless, he suggests that the operational concepts of conservation are acquired by the child through interaction with his 'total' environment. (Mermelstein et al, 1967 p. 186)

The present study, apparently like many of those predating it, is based on the proposition that if the possession of the conservation operations increases the child's adaptability in everyday living (Bruner, 1966) and that operational concepts are acquired through experience, a knowledge of the salient features of the

environment which are functionally related to the acquisition of conservation operations could be useful in accelerating conservation acquisition. Furthermore, such knowledge could be helpful in making decisions with respect to the how, what, when, and why questions involved in teaching children.

An application of principles developed from research on behavior modification or learning, to the problem of generating more knowledge about the acquisition of conservation operations, appeared promising since such an application had not been explored completely. Accordingly the problem was addressed from that perspective.

General Problem and Delimitation

The present study was an attempt to discover more about the conditions either natural or contrived, but both necessary and sufficient, with which a child must interact to assure his successful performance on all the conservation tasks he encounters. Of particular concern were the patterns of stimulus conditions encountered, changes in the stimuli perceived, and the possible role reinforcement has in changing the way children behave *vis à vis* the patterns, and changes in patterns, of visual stimuli. More specifically the problem was one of determining the degree to which the stable and generalized conservation of substance response is functionally related to controlled experience involving successive

approximations and selective reinforcement. That is, the shaping of behavior, through a series of tasks which manifest gradual but systematic changes in behavior - eliciting stimulus conditions and selective reinforcement patterns, was investigated as a possible process or experience through which the reliable, generalized and durable conservation operation is acquired.

The experiment was limited to an investigation of the acquisition of the conservation of substance since it is held that the postulates advanced are adquately tested through experimentation in one area only (Lefrançois, 1966).

CHAPTER II

THEORETICAL ORIGINS OF THE PROBLEM AND REVIEW OF RELATED LITERATURE

Introduction

From many years of clinical observation and quasi-experimental work,Jean Piaget and his associates have developed a theory of human development which is essentially a qualitative description of the development of intelligence. Piaget's biological sciences background is reflected in his theory of child development in that his conception of development constitutes a theory of adaptation. For Piaget, (1967) adaptation involves maturation, experience, and the changes brought about by the interaction of these phenomena in the human organism. Through this process the child develops intellectual structures (schemas) which enable him to adapt more efficiently to the demands of his environment. Thus adaptation and organization can be conceived of as defining intelligence for Piaget (ibid).

Two complementary processes are involved in the aforementioned development, elaboration, and organization of the cognitive structures or schemata,which are defined as internalized, repeatable actions (Sullivan, 1967 b, p.1). One is assimilation: the process by which the organism incorporates new objects or events into patterns of behavior by using its present repertoire of mechanisms. The other is accommodation: the process of change in the

organism's schemata which enable the organism to adjust to the demands of phenomena to which, prior to the change, he could not adapt.

It has been suggested that Piaget's theory describes human ontogeny in terms of the acquisition of a logical progression of these intellectual structures, which progression is invariant (Lefrançois, 1967) and natural (Mermelstein et al, 1967). When actions beget the internalized structures the structures become elaborated and organized as the child assimilates and accomodates while interacting with various phenomena or attributes of these phenomena. Novel stimuli act as aliment for consolidation and changes in the structures. These structures can then become "groupements" which are systems of structures whose stability depends on their having five logical properties (Berlyne, 1957).

> Unless these properties are present, the relations between the elements of a grouping will change as attention is directed to different parts of them, as happens with perceptual patterns, and thought will not be immune from inconsistency (ibid, p. 318).

These five properties are:

1. Closure - any two operations may be combined to form a third.
2. Reversibility - for any action there exists an opposite action which can cancel it.
3. Associativity - if three or more operations are combined no difference results from the order of the combinations.

4. Identity - there are some actions which leave objects unchanged.

5.(a) Tautology - a classification or relation which when repeated is not changed.

5.(b) Iteration - the repetition or combination of a number with itself produces a new number. (Lefrançois, 1967)

With the development of these groupings the child is said to be able to classify, order and number objects and events that are concrete and immediate. That is to say that the child has acquired the ability to perform operations (actions that are internalized and reversible.) Hence, "concrete operations" is the name given to this period.

However some operations are beyond his capabilities at this stage in his development. Thus operations on hypothetical objects, events and situations cannot be performed by the child at this stage. Just as the pre-operational stage child, whether he be in the "sensori-motor" period, the "preconceptual thought" period or the "intuitive thought" period is unable to classify, order, or number concrete objects and events, the child at the concrete operational level is unable to reason from the possible to the actual, or from the actual to the possible. (Ibid. p. 169). Thus the child develops from a pre-operational stage through a concrete operations stage to a formal operations stage the last of which is characterized by the ability to perform operations on the hypothetical.

Perspectives of Accumulated Research

Although Piaget's theory suggests how these operational capabilities are acquired he has not consistently supported his theory empirically.

It is not surprising, then, that many researchers have advanced and tested a variety of hypotheses about how the operations become part of the child's behavioral repertoire(Lovell and Ogilvie, 1960; Wohlwill, 1960; Smedslund, 1961a, 1961b, 1961c, 1961d, 1961e, 1961f; Wohlwill and Lowe, 1962; Smedslund, 1962; Beilin, 1964; Braine, 1964; Bruner, 1964; Feigenbaum and Sulkin, 1964; Wallach and Sprott, 1964; Beilin, 1965; Gruen, 1965; Brison, 1966; Bruner, 1966; Siegel, Roeper, and Hooper, 1966; Soenstroem, 1966; Brison and Bereiter, 1967; Carlson, 1968; Côté, 1968, Lefrançois, 1968; Sigel and Hooper, 1968; Smith, 1968; Towler, 1968; Winer, 1968). The focus of the researchers has usually been on those attributes which characterize the emergence of, and developments within, the period of concrete operations. More specifically, their attention has been centred on one of Piaget's key concepts: the conservation operations and their acquisition. The theoretical significance of Piaget's conservation construct is stressed by Flavell (1963):

> It was an act of creative inspiration when Piaget hit upon the idea that a wide variety of cognitive areas - number, quantity, time, and so forth - are in certain crucial respects mastered according to a common procedure: to discover what values do and do not remain invariant (are and are not conserved) in the course of any given

> kind of change or transformation; ... There is no question but that the formations of concrete operations is the richest chapter in Piaget's developmental story .... . It does not seem likely that all this would or could have come about without the concept of conservation - formation and related unifiers (p. 415).

Importance of the Research and an Evaluation

Conservation as manifested by consistent, durable responses to the invariant properties of objects in the face of transformations,is for Piaget, a central prerequisite for the acquisition and subsequent development of logical thought. Accordingly, the work of the aforementioned researchers can be regarded as attempts to clarify and understand the processes involved in the acquisition of the conservation operations. In addition, however, it could be argued that the matter is not merely an academic question of clarification, since decisions about curricula design and teaching strategies could be greatly affected by an understanding of these processes. That is, the results of the aforementioned research could provide an empirical basis for decisions about when to teach what to whom, in what sequence, and how.

Regretably, the results obtained have been equivocal and tend to support Piaget's (Mermelstein et al, 1967), contention that specific training plays little or no role in the acquisition of the conservation operations.

Derivation of Current Postulates and Hypotheses

Mermelstein (1967) has suggested that the approaches to training for conservation, for which success is claimed, can be grouped into four categories representing the various theoretical positions described in the literature; (a) cognitive - conflict training - illustrated by Smedslund's (1961) works; (b) multiple classification training - (Sigel, 1966); (c) verbal rule training (Beilin et al, 1966); (d) language activation training - (Bruner, 1966). An examination of recent work in conservation studies suggests that the number of categories might be increased. For example, Sullivan's (1967) film modeling technique, and Brison and Bereiter's (1967) social interaction approach do not appear to fit Mermelstein's (1967) categories. Inspite of the diversity of approaches used, it is interesting to note that no category wittingly encompassing S-R principles is included. Such an absence is likely due to the rather wide-spread acceptance of Smedslund's (1961a, 1961c) claims to have tested the efficacy of a so called "learning theory" explanation of conservation acquisition and found in wanting. However, Smedslund (ibid) appears to have ignored the basic principles of learning enunciated by Skinner (1953). Furthermore, Smedslund's (ibid) apparent inattention to the basic principles of learning is not an isolated case. It would seem that those like Wohlwill and Lowe (1962) who claim to

be testing the efficacy of learning theory in conservation acceleration, invariably ignore such fundamental considerations as shaping through selective reinforcement on successive approximations, schedules of reinforcement, and their effects on the acquisition, generalizability, and durability of behavior patterns. The literature on conservation training lacks any evidence of attempts to investigate the effects of applying Skinnerian learning principles in training for conservation acquisition. As a consequence, no one can claim success for this approach nor can it be claimed that such an approach is not successful. If Piaget's criteria (reliability of emission, generalizability, durability) for asserting the presence of an operation are re-examinated one begins to understand why Smedslund's alleged test of "learning theory" yields negative results.

According to Mermelstein et al (1967), Inhelder (1963), and Piaget (1964), an operation is not fully acquired if it is not reliable, that is, is not consistently emitted where and when appropriate, is not durable, that is if it extinguishes, and is not generalized, that is, is not manifested in a variety of analogous situations. Accordingly, it is not surprising that Smedslund (1961a, 1961c) could claim that "learning theory" was ineffective in inducing the conservation operation since he apparently did not try to "shape" the behavior and used continuous reinforcement only - an approach which has been shown to

almost guarantee extinction of the behavior in question (Skinner, 1953; Long, 1958; Reese, 1966, Orlando and Bijou, 1964; Staats and Staats, 1966.) That is, when reinforcement is withdrawn after a continuous schedule has been in effect, the behavior that has been reinforced will extinquish very rapidly following a brief period in which the emission rate increases.

How then, does one produce a reliable, generalized and durable operational response? Perhaps an analysis of what is involved in the "natural acquisition" of the conservation operations in terms of the learning principles described by Skinner (1953) and Staats and Staats (1966) would be helpful in the production of a description of the necessary and sufficient conditions which produce a reliable, durable, and generalized conservation behavior.

Piaget acknowledges that operations are acquired through the interaction of the child and his environment. The importance of experience involving activity on the part of the child is stressed (Smedslund, 1961, p. 13). Now, as Skinner (1953) and Staats and Staats (1966) have suggested, actions or behavior can be instrumental in obtaining reinforcement for the actor. When the reinforcement is obtained in certain patterns, it can shape the actors behavior. That is, differential reinforcement can shape behavior and behavior can wittingly be shaped with reinforcement on successive approximations to a preselected goal behavior (Skinner, 1953, pp. 91-106;

Staats and Staats, 1966, pp. 77-86). In addition, once the behavior has been shaped it will be maintained and its durability assured if the behavior is instrumental in procuring reinforcement intermittently (Staats and Staats, 1966, pp. 61-70). Furthermore, the response can be generalized to situations with variations in their stimulus properties by means of the processes of discrimination and generalization if the response has been emitted in a variety of stimulus conditions which have some common element(s) and if the emission has been followed by reinforcement.

Accordingly, it is held that a conservation acceleration training technique incorporating the aforementioned principles might be developed along the following lines. In order to assure the acquisition of a conservation response, a series of progressively larger deformations of an initial stimulus pattern could be presented to each S. This series would begin with an imperceptible deformation and terminate with a very gross deformation. Thus the conservation response, where S reports that the stimulus objects still contain the same amount (or still differ), would be emitted from the outset. Continuous reinforcement would likely maintain and strengthen the responses due to the principle of reinforcement which may be stated as follows "When certain stimuli closely follow a certain behavior they increase the probability of that behavior occuring again in the future" (Staats and Staats, 1966, p. 47). Furthermore, the association of the response with an

increasingly diverse number of stimulus patterns, followed in close contiguity by reinforcements in each case, would tend to increase generalization and discrimination. A change to variable-interval - variable-ratio reinforcement schedules and a continuation of the training sequence involving an exposure to a wide range of stimulus variation, would assure the durability of the response (Staats and Staats, 1966; Skinner, 1953).

Accordingly, it was postulated that the acquisition of conservation operations can be accelerated through the application of S-R. learning principles. This included successive approximations, or shaping with a complex of reinforcement schedules, the former consisting of the gradual development of an association of conservation responses with a wide range of deformations, and the latter consisting of an initial continuous schedule for rapid acquisition and shaping differential responses, and a subsequent intermittent schedule to provide for the assurance of response durability. Further, it was postulated that the intermittent reinforcement would assure the durability of the conservation operation since a variable interval schedule produces the longest extinction curves of any schedule (Reese, 1966 p. 18); and the shaping involving a range of initial stimulus conditions and subsequent deformations with differential reinforcements would facilitate generalizability. (Staats and Staats, 1966). Specific tests of these postulates are developed in the following chapter.

CHAPTER III

HYPOTHESES

The following hypotheses were suggested by the foregoing postulates and the considerations from which the postulates were derived.

The first two hypotheses were concerned with the feasibility of promoting conservation-like behavior through training involving shaping with successively larger deformations and external reinforcement. (The term "conservation-like" is used since the criterion of durability could not be tested on the first posttest (PT-I). Accordingly the presence of the conservation operation could not be determined at PT-I.)

H_1: At PT-I, Ss who received reinforcement during successive approximations training will emit conservation-like responses significantly more often than Ss who were not trained (CL-1, Ss).

H_2: At PT-I, no significant difference will exist, with respect to the emission of conservation-like responses, between trained Ss who received reinforcement according to a multiple schedule (IR-2 Ss) and trained Ss who received reinforcement according to a continuous schedule (CR-3 Ss).

The third, fourth and fifth hypotheses were

concerned with the feasibility of accelerating the acquisition of the conservation of substance operation through the selective application of reinforcement to responses to a series of succeedingly larger deformations. Only at the second posttest (PT-2) was it possible to test the durability criterion. Accordingly, the latter three hypotheses were designed to test whether one of the treatment conditions, namely the multiple schedule (IR-2) condition, was more efficacious in producing the conservation operation (conservation behavior which was not only reliable and generalized but durable, that is, resistant to extinction, as well).

H_3: At PT-2, Ss who received reinforcement according to multiple schedules (IR-2) during successive approximations training, will have acquired the conservation of substance operation significantly more often than Ss who received reinforcements according to a continuous schedule (CR-3) during the same training regimen.

H_4: Ss who were trained with the multiple schedules (IR-2) will exhibit the conservation of substance operation, significantly more often than Ss who received no training (CL-1), at PT-2.

H_5: At PT-2, there will be no significant difference between the control group (CL-1) and the training group receiving continuous reinforcement only (CR-3) with respect to the number of Ss who demonstrate the presence of the conservation operation.

CHAPTER IV

METHOD

Subjects

A sample of 33 Ss were selected from the population of all children enrolled in two urban kindergartens in Edmonton. Ss were given two pretests to determine their elegibility for inclusion in the sample. The purpose of the first pretest was to determine whether Ss had an operational understanding of the key terms in the training and test questions. The second pretest tested for the presence of stable conservation-like behavior. Only those Ss who passed all items in the first pretest and failed all items in the second pretest were randomly assigned to the experimental and control groups. Forty-one prospective Ss were pretested and 8 of these failed to meet the pretest criteria. The remaining 33 Ss were assigned to the three conditions with 11 Ss in each. The Ss's ages ranged from 56 months to 76 months with a mean age of 68.42 months and a standard deviation of 5.3147 months. The Ss' Harris-Goodenough intelligence scores ranged from 82 to 122 with a mean of 98 and a standard deviation of 9.4899. Blishen S.E.S. scores for the Ss ranged from 32.14 to 76.01 with a mean of 59.22 and a standard deviation of 14.5265. The data presented in Table I consist of the means and standard deviations for age, socio-economic status and intellectual maturity of the three groups and the total

TABLE I

AGE, SOCIO-ECONOMIC STATUS, AND INTELLECTUAL ABILITY DATA FOR ALL Ss (MEANS, STANDARD DEVIATIONS AND ANALYSES)

Group	Age (in months)	Blishen S.E.S. Scores (Socio-economic status)	Harris-Goodenough (Intellectual Ability)
Control Group (CL-1) (N=11)	Mean: 67.1818 S.D.: 5.7590	Mean: 59.9999 S.D.: 15.4501	Mean: 97.6364 S.D.: 9.8520
Intermittent Rein. Group (IR-2) (N=11)	Mean: 69.2727 S.D.: 5.9009	Mean: 60.3317 S.D.: 16.2155	Mean: 96.0909 S.D.: 6.9785
Continuous Rein. Group (CR-3) (N=11)	Mean: 68.8181 S.D.: 4.7504	Mean: 57.3199 S.D.: 13.7376	Mean: 100.2727 S.D.: 11.9006
Total Sample (N=33)	Mean: 68.4242 S.D.: 5.3147	Mean: 59.2172 S.D.: 14.5265	Mean: 98.00 S.D.: 9.4899
Statistical Analysis			
Homogeneity of Variance test	$X^2 = 0.5149$ probability= 0.7730	$X^2 = 0.2720$ probability= 0.8729	$X^2 = 2.6085$ probability= 0.2714
Analysis of Variance	F 0.44 P 0.6488	F 0.13 P 0.8784	F 0.51 P 0.6038
Probabilities from Scheffe multiple comparison of means	(CL-1,IR-2)0.6750 (CL-1,CR-3)0.7851 (IR-2,CR-3)0.9814	(CL-1,IR-2)0.9987 (CL-1,CR-3)0.9180 (IR-2,CR-3)0.8976	(CL-1,IR-2)0.9339 (CL-1,CR-3)0.8202 (IR-2,CR-3)0.6103
Multivariate analysis (Wilk's Lamda Test)		probability level = 0.8778	

sample, as well as the products of analyses carried out with these means, variances and standard deviations. The objective of these analyses was to determine whether or not the three groups came from the same population. The population from which the sample was drawn had a high female to male ratio and the sample used in the present study reflected that fact (22 females to 11 males). Table II presents the data on the composition of the groups, as well as the total sample, by sex.

These data, presented in Tables I and II, indicate that the Ss in groups CL-1, IR-2, and CR-3 come from the same population when the age, intellectual ability and socio-economic status variables are considered each by itself or all three together (See the bottom half of Table I for probability levels). Consequently, no significant proportion of any variance produced in behavior, may be accounted for by differences in these variables, taken singly or cumulatively.

Outline of Procedure

All Ss were: (a) given two selection pretests, (b) tested for a measure of intellectual ability, (c) exposed to one of the three conditions in the experiment, (d) given two conservation of substance posttests, and (e) classified according to Blishen's (1967) scale for ranking socio-economic status. With the exception of the testing for intellectual ability, all testing and training was carried

TABLE II

COMPOSITION OF GROUPS BY SEX

Group	Male	Female	Totals
CL-1 (Control	5	6	11
IR-2 (Interm. Reinf.)	3	8	11
CR-3 (Contin. Reinf.)	3	8	11
Total Sample	11	22	33

out individually with only E and his assistant present.

The purpose of the first pretest (Selection Pretest One) was to ensure that all Ss possessed an operational understanding of the terms "same", "more than", and "less than". Selection Pretest Two was intended to ensure that all Ss did not demonstrate a presence of the conservation of substance operation.

The three conditions to which Ss were randomly assigned included: (a) the control or no training condition (CL-1); (b) a training condition which incorporated both continuous and intermittent reinforcement schedules and 98 successive approximations tasks (see Appendix B) distributed over 4 training sessions between which a mean period of 4 days intervened (IR-2); (c) a training condition which, excepting for the pattern of reinforcement applications, was identical to the IR-2 condition. In this third condition reinforcement was dispensed according to a continuous schedule only (CR-3).

The purpose of the first postest (PT-I) was to test for (a) treatment effect, (b) reliability or consistency of Ss' emissions of conservation behavior, and (c) response generalization. Posttest two (PT-2) was designed to test for response durability, or resistance to extinction, as well as reliability and generalizability of the conservation behavior. Accordingly PT-2 tested for the presence of the conservation of substance operation.

The order and average times (a.t.) of present-

ation for each item of procedure are represented in Figure 1. (The Procedural Flow Chart).

Selection Pretest One

All prospective Ss were shown four transparent beakers which were identical in size and shape. Two of the beakers contained equal amounts of liquid while one of the remaining two contained more, and the other less, than the pair with equivalent amounts. Each child was first asked to touch two glasses containing "the same amount". Then he or she was asked to choose two glasses which had different amounts of liquid and indicate, by touching, which beaker had "more than" the other, and which had "less than" the other. Failure to carry out correctly, any one of these tasks, disqualified a child from inclusion in the sample of the present study.

Selection Pretest Two

Prospective Ss were pretested for conservation of substance in the following manner. Each child was given three conservation tasks consisting of three different deformations of liquid. After each of the three deformations, detailed below, prospective Ss were asked "Do you think this glass (indicating the beaker which had just received contents) has the same amount of juice, more juice, or less juice than this one?" (indicating the beaker whose contents had not been removed). The order of the phrases

PROCEDURAL FLOW CHART SHOWING ORDER
AND AVERAGE TIMES (at) OF PRESENTATION

I Day 1

(i) Pretest One (at 2 min.) (ii) Pretest Two (at 3 min.)
(iii) Ss Random Assignment to Groups CR-3, IR-2, and CL-1)

II Day 2

CONTINUOUS SCHEDULE REINFORCEMENT TRAINING GROUP (CR-3)	MULTIPLE SCHEDULE REINFORCEMENT TRAINING GROUP (IR-2)	CONTROL (NO TRAINING) GROUP (CL-1)
(i) Draw-a-Man Test (at 10 min.) (ii) Successive Approximations Training: with continuous schedule reinforcement (at 20 min)	with continuous schedule reinforcement (at 20 min)	NO TRAINING

FOUR DAY INTERLUDE

III Day 7

Successive Approximations training: with continuous schedule reinforcement (at 15 min)	with continuous schedule reinforcement (at 15 min)	NO TRAINING

FOUR DAY INTERLUDE

IV Day 12

Successive Approximations training: with continuous schedule reinforcement (at 15 min)	with Intermittent (Variable) schedules of reinforcement (at 15 min)	NO TRAINING

FOUR DAY INTERLUDE

V Day 17

Successive Approximations training: with continuous schedule reinforcement (at 15 min)	with Intermittent (Variable) schedules of reinforcement (at 15 min)	NO TRAINING

SEVEN DAY INTERLUDE

VI Day 24

Posttest One (PT-I) (at 10 min)
For All Groups

TWENTY-ONE DAY INTERLUDE

VII Day 46

Posttest Two (PT-2) (at 10 min)
For All Groups

FIGURE 1

describing the amount was systematically changed on each occasion. Any child who emitted one or more correct responses to the question during Pretest Two was disqualified for inclusion in the sample.

On the first task of Pretest Two prospective Ss were shown three cylindrical beakers. Two of the beakers were 3 inches in height with 7/8 inch diameters. After the prospective Ss acknowledged that the identical beakers contained the same amount of liquid, the contents of one of these containers were poured into the empty third beaker (1½"h x 2¼" d). The standard question, as above, was then asked.

In the second task of Pretest Two the same apparatus was used. However, the identical beakers in this task contained amounts of liquid which clearly differed. Thus, on this second task, after prospective Ss had acknowledged that one beaker contained more than the counterpart, the contents of the glass with the greater amount of liquid were transferred to the squat beaker. At this point the standard question was asked again.

In the third task of Pretest Two, a pair of beakers, identical to the shorter one described above (1½"h. x 2¼" d.) were used as the initial containers. The third beaker was identical to the taller glasses described above (3"h x 7/8"d). After the identical beakers were acknowledged to contain the same amount, the contents of one of them were poured into the taller, thiner, glass. Again the standard question was asked.

Only those children who made no correct responses to the Pretest Two items were selected for the sample.

Intellectual Ability

The Goodenough Draw - A-Man test (Harris, 1963) was administered to all Ss in an attempt to acquire some estimate of their mental ages. It has been suggested that this test while having lower reliability and validity indices than other more time-consuming and uneconomical tests, serves adequately to yield approximate scores that can be used to control, experimentally, for a characteristic which may account for some of the variance in receptivity to training (Lefrançois, 1966). The testing was administered by E in the company of two assistants.

Socio-economic Status (S.E.S.)

The Blishen (1967) Socio-Economic Index for occupations in Canada was used to assess Ss S.E.S. since Lefrançois (1966) suggests that S.E.S. may be correlated positively with attainment of success in conservation tasks. The necessary information with respect to fathers' occupation was obtained from the kindergartens and/or directly from Ss' parents.

Training Procedure

All Ss interacted individually with E who tried to maintain a pleasant demeanor and purposive manner throughout each

session. The four training sessions were of 15 to 20 minutes duration and involved only those Ss assigned to the two experimental groups. A mean period of four days intervened between training sessions. All experimental Ss were exposed to an identical set of training items, (see Appendix B) and were given identical posttests which are described below.

After a standard orientation procedure (see Appendix A) had been completed on the first day of training, each S was exposed to a pre-set number of training items (see Appendix B), each element of which was followed by F asking the standard question as described above for Pretest Two (see also Appendix A Part (c)). All experimental Ss were exposed to all the training items listed in Appendix B. Figure I shows the order of proceedings with average time taken for each phase (p. 23).

The first training session consisted of 26 deformations. The remaining three training sessions consisted of 24 deformations each. In all sessions the sequence of deformations was arranged to incorporate succeedingly larger deformations as the training proceeded from the initial imperceptible deformation toward the greatest deformation that is possible.

Ss in the CR-3 group were reinforced for every correct response emitted throughout the entire training sequence. Ss in the IR-2 group were reinforced in the same manner as CR-3 Ss for the first two training sessions,

but were reinforced intermittently thereafter. That is, IR-2 Ss were reinforced on a variable schedule so that not all correct responses emitted during the last two training sessions resulted in the issuance of reinforcement. The number of correct responses that were emitted and the periods of time which passed between the applications of reinforcement varied. However, as the last two training sessions progressed, there was an effort made by E to gradually, but not systematically, increase the number of non-reinforced correct responses, and the time, between reinforcement applications. Figure 2 illustrates the type of reinforcement schedule employed with IR-2 Ss during the last two training sessions (p. 28).

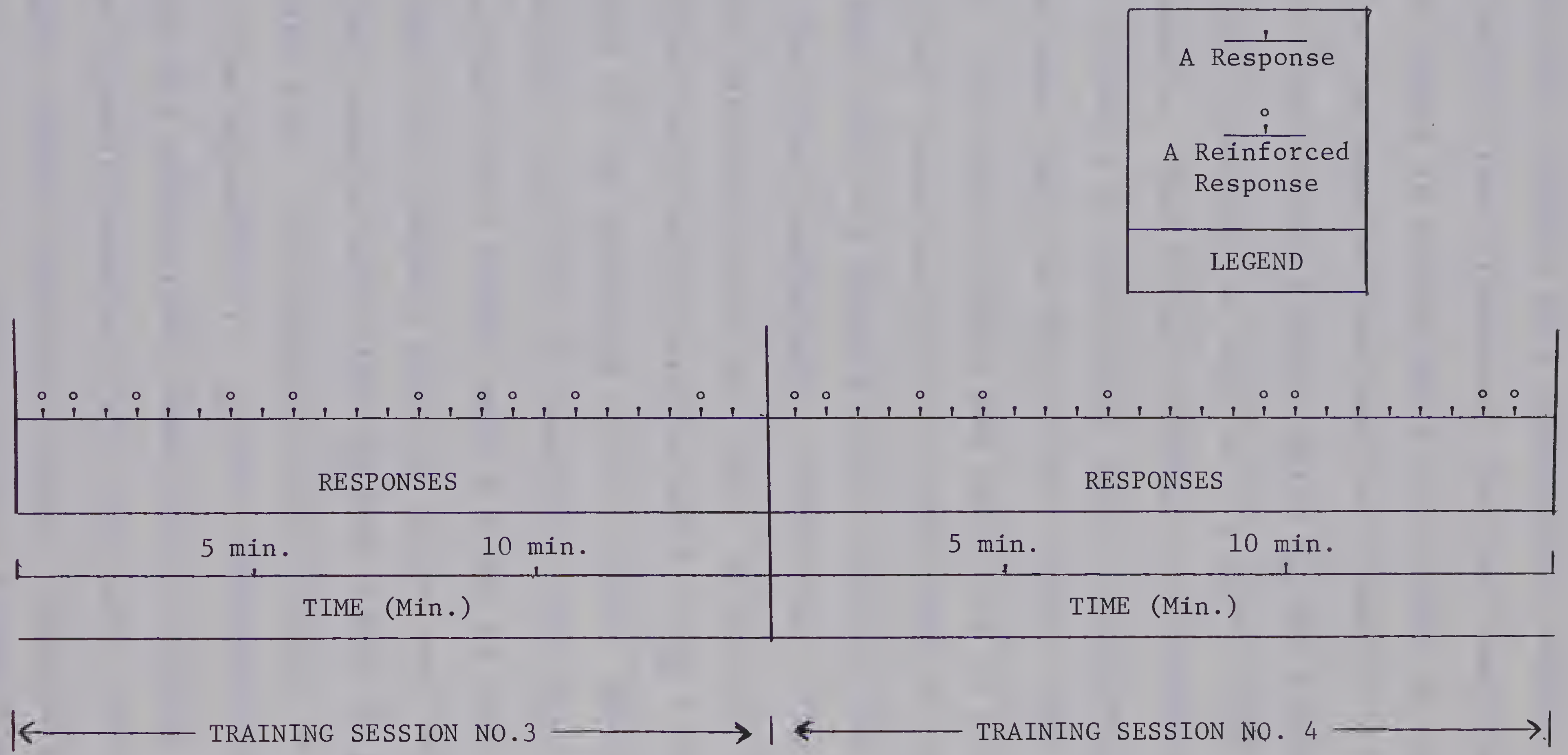
Posttests

All Ss were given two posttests. The first posttest (PT-I) was administered one week after the training of Ss in the two experimental groups had ceased. Ss underwent a second posttest (PT-2) four weeks after the training program was completed.

Posttest One (PT-I)

Six deformations which had not been encountered by Ss during training procedures were utilized in PT-I. Three of the six test items consisted of deformations of liquid while the remaining three tests involved deformations of plasticine. The apparatus for the tests with liquid

A GRAPHIC ILLUSTRATION OF THE TYPE OF REINFORCEMENT SCHEDULE EMPLOYED IN TRAINING SESSIONS THREE AND FOUR WITH IR-2 Ss



NOTE: The figure illustrates how the time intervals must vary if a variable ratio schedule is employed and the number of responses between reinforcers (ratios) must vary if a variable interval schedule is employed. That is, a variable interval and a variable ratio schedule are indistinguishable from one another when the present training contingencies are operating.

FIGURE 2

deformations included four transparent beakers, two of which had 3/4 inch diameters. The two remaining beakers were 2½ inches in height and 2 5/8 inches in diameter. The first deformation involved the transfer of the contents of one of the stubby glasses which Ss had acknowledged as initially containing as much as its mate, into one of the tall beakers. The second deformation consisted of a transfer of the contents of the stubby beaker acknowledged by Ss to have less than its twin at the outset, into a tall beaker. Deformation three was identical to the second except that there was initial equivalence of contents and there were two tall glasses which received the liquid of one of the squat containers. Items four, five and six involved deformations of one ball, in each of three pairs of plasticine balls which were declared by Ss to be the same in amount at the beginning of each task. Specifically, those deformations consisted of changing a ball into the shape of (a) a pancake, (b) a cross, and (c) a cup or bowl. All Ss were asked the standard question after each deformation, and after answers were given Ss were asked by E "Why do you think so?" All responses were recorded on a special form. (See Appendix C). Ss were adjudged to possess a reliable and generalized conservation response if they (a) gave correct answers to all six tests, and (b) gave "symbolic" and/or "symbolic-logical" explanations (Smedslund 1961, b) to justify their answers. Symbolic explanations were deemed to be those "...which directly or indirectly

refer to previous events in the same test item" (ibid, p. 74). For example, statements like "they were the same when they were in the same kind of glasses" would be of a "symbolic" type. "Symbolic-logical" explanations were those responses "...which explicitly state that nothing has been added or taken away, or which in any other way contain an explicit referenced to necessity" (ibid , p. 74). All other explanations were judged to be inadequate. Accordingly, PT-I was designed to test for the acquisition of a reliable and generalized response about which one could make inferences with respect to the presence of a conceptual or cognitive dimension of the trained conservation responses. Thus, the requirement of all correct responses to meet the reliability of emission, or consistency, criterion as well as the generalizability criterion was matched by the requirement of adequate explanations for all responses. An equal consistency or reliability in the emission of"symbolic" and/or "symbolic-logical" explanations for the correct answers was deemed to be a rigorous test of the evidence used for inferring the presence of a conceptual or cognitive dimension of the conservation behavior.

Nevertheless, one criterion remained to be tested after PT-I. The conservation behavior had to be not only reliable and generalized; it had to be durable, that is, resistant to extinction if one was to assert the presence of the conservation of substance operation. Posttest two (PT-2) was primarily designed therefore,

to test not only for consistency and generalizability but for durability.

POSTTEST TWO (PT-2)

PT-2 was identical to PT-1 except that it was administered four weeks after training had terminated (as opposed to the one week wait for PT-1) and incorporated two novel, additional deformations of plasticine. Thus, eight tasks were included in PT-2. The first of the additional deformations involved the changing of one of two balls (acknowledged by Ss to be initially equivalent in amount) into a "snake". The second addition followed the snake deformation immediately. A necklace was constructed from the snake, the completion of which construction, was followed by the standard questions. As in PT-1, correct responses accompanied by symbolic and/or symbolic-logical explanations served as the pass-fail criteria for the posttest. However, at PT-2 the durability of the conservation behavior was also held to be tested since four weeks had passed since training terminated. Accordingly, if Ss met the PT-2 criteria they were deemed to possess the conservation of substance operation.

CHAPTER V

RESULTS

The results are presented in two parts. In both parts Fisher's Exact Z (Siegel, 1956, pp. 96-104) was used to assess the significance of the findings. This non-parametric approach was used for two reasons. First, since only a perfect score of all correct answers was accepted as being evidence of the presence of conservation, the criterion data was clearly dichotomous. Second, since the N for each group was less than 15 and there was an invariable incidence of at least one small cell frequency in each contingency table, the appropriateness of the Fisher test became very apparent.

Part One is an evaluation of the first two hypotheses in terms of an analysis of the data from the first posttest (PT-1) which was administered one week after training had ceased. Part two is an evaluation of hypotheses three, four, and five, in terms of an analysis of the data from the second posttest (PT-2), which posttest was administered four weeks after the cessation of training.

Analysis of Data, Part One: Evaluation of Hypotheses One and Two

The first hypothesis (H_1) predicted that Ss who were trained would exhibit conservation behavior significantly more frequently on PT-1 than Ss who received no training. That is, H_1 predicted that those Ss who were reinforced for emitting conservation responses to a series of succeedingly

larger deformations on the appearance of substance would emit conservation responses more frequently and consistently than Ss receiving no training, when given test items one week after training had ceased. This prediction was evaluated by comparing the performance of each of the two training groups on PT-1 with that of the control group on the same posttest.

Although PT-1 included three deformations of the same substance, colored water, used in training, PT-1 results, presented in Tables III and IV, indicate not only frequency and consistency of response emission; but they indicate response generalization as well since the remaining three posttest items involve deformations of plasticine, a substance that differs in its physical qualities from the substance used in training. Furthermore, the three items involving colored water were not identical with any of the training items.

The data presented in Table III indicates that the Ss in the two training groups emitted conservation responses significantly more often than those Ss in the control group. While the Ss in the control group (Cl-1) failed to emit any conservation responses on the 66 opportunities to do so the Ss who received multiple-schedule reinforcement on successive approximations training (IR-2) and Ss who received reinforcement on a continuous schedule during successive approximations training (CR-3) emitted 66 and 61 conservation responses respectively. One S in the CR-3 group accounted for all five of the non-conservation responses emitted by trained Ss. Thus with one exception, all trained Ss appeared to have

TABLE III

POSSIBLE AND ACTUAL CONSERVATION RESPONSES ON THE FIRST POSTTEST (PT-I) GIVEN ONE WEEK AFTER TRAINING CEASED

Subjects	Number of Possible Conservation Responses	Actual Number of Conservation Responses Made
Control Group (CL-1) (N=11)	66	0
Multiple Schedule Group (IR-2) (N= 11)	66	66
Continuous Reinforcement Group (CR-3) (N=11)	66	61

TABLE IV

SS THAT EMITTED THE CONSERVATION RESPONSE FOR ALL SIX ITEMS ON POSTTEST ONE (PT-1) GIVEN ONE WEEK AFTER TRAINING CEASED

Subjects	Ss That Emitted Conservation Responses to All Six Test Items	Ss That Filed to Emit Conservation Responses to All Items
Control Group (CL-1) (N=11)	0	11
Multiple Schedule Group (IR-2) (N=11)	11	0
Continuous Reinforcement Group (CR-3) (N=11)	10	1

acquired the conservation response.

Since the criterion of correct responses to all six deformations, accompanied by the same number of symbolic and/or symbolic logical explainations, was used to assert the presence of a reliable and generalized conservation response, Ss were categorized on overall performance on PT-1. The data in Table IV indicates that the trained Ss exhibited significantly more conservation behavior than Ss in the control group. The significance levels ($P < .005$ on a one-tailed test in both cases) are presented in Table V.

While none of the Ss in CL-1 emitted conservation responses to all six items, all 11 Ss in IR-2 and 10 out of 11 Ss in CR-3 gave correct responses and symbolic and/or symbolic-logical explainations for all six test items.

These data then, clearly indicate support for the first hypothesis (H_1) which predicted that PT-1 would demonstrate a significant difference between control and trained Ss with respect to the emission of the reliable and generalized conservation response.

The second hypothesis (H_2) predicted that there would be no significant difference between the two training groups with respect to conservation behavior in evidence at PT-1. This prediction was evaluated by comparing the PT-1 performance of the Ss in IR-2 with that of Ss in CR-3. The data in Table III indicates that the IR-2 group responded appropriately on all 66 items while CR-3 Ss emitted 61 conservation responses for the same 66 trials. Since one S

TABLE V

POSTTEST ONE (PT-1) RESULTS OF TREATMENT GROUPS (IR-2, CR-3) COMPARED TO A CONTROL GROUP (CL-1) USING FISHER'S EXACT Z

	-	+
CL-1	11	0
IR-2	0	11

(One tailed test) $P < .005$
(Two tailed test) $\alpha < .01$

	-	+
CL-1	11	0
CR-3	1	10

(One tailed test) $P < .005$
(Two tailed test) $\alpha < .01$

	-	+
IR-2	0	11
CR-3	1	10

(One tailed Test) $P > .05$
(Two tailed test) $\alpha > .10$

in the CR-3 group accounted for the 5 non-conservation responses accumulated by CR-3 Ss, Table IV indicates that the generalized conservation response was reliably emitted by 10 out of 11 CR-3 Ss whereas 11 out of 11 IR-2 Ss emitted appropriate responses for all PT-1 items. The non-conserving S in CR-3 gave correct responses to two of the deformations and gave one symbolic explaination for one of the two correct responses she made. Thus the additional conservation response produced thereby accounts for the addition of one conservation response to the total of 60 accumulated by the other 10 Ss. Thus Table III reports 61 conservation responses for the CR-3 group on PT-1.

Although there is a difference between the IR-2 and CR-3 groups on PT-1 performance, it is not significant ($P>.05$, see Table V). The data presented in Tables III, IV and V therefore indicate support for the second hypothesis (H_2) which predicted that no significant difference with respect to conservation behavior of Ss in the two training conditions, would be discernable at the first posttest (PT-1).

Analysis of Data, Part Two: Evaluation of Hypotheses Three, Four, and Five

The third hypotheses (H_3) predicted that those Ss who received training incorporating a complex of reinforcement schedules, that is, multiple-schedule reinforcement (group IR-2), would retain the conservation response to a significantly greater degree than Ss who received continuous reinforce-

ment but otherwise had the same training (CR-3). Thus on posttest two (PT-2) IR-2 Ss were predicted to exhibit a reliable, generalized and durable conservation response (the conservation operation) in a significantly greater frequency than CR-3 Ss. This prediction was evaluated by comparing the PT-2 performance of IR-2 Ss with that of Ss in CR-3. Tables VI and VII, to be discussed in detail below, present the results of all Ss' performance on PT-2.

The second posttest (PT-2) consisted of eight deformations, the first six of which were identical to the items on PT-1 and the remaining two of which were novel deformations of plasticine - not encountered by Ss in training or testing. Thus PT-2 tested for response durability, reliability of emission, and generalization. The appending of the two additional deformations was intended to extend the test for response generalization.

The data presented in Table VI indicates that the IR-2 Ss did not differ in conservation behavior from CR-3 Ss on PT-2 items. Both conserved on 82 of the 88 opportunities to do so.

The data presented in Table VII indicates that not only did Ss in IR-2 emit precisely the same number of conservation responses as CR-3 Ss; it also indicates that there was an identical number of Ss in the CR-3 and IR-2 groups that met the conservation operation criteria. Ten of the 11 Ss in each of the IR-2 and CR-3 groups gave correct responses and symbolic and/or symbolic-logical explainations for all

TABLE VI

POSSIBLE AND ACTUAL CONSERVATION RESPONSES ON THE SECOND POSTTEST (PT2) GIVEN FOUR WEEKS AFTER TRAINING CEASED

Subjects	Number of Possible Conservation Responses	Actual Number of Conservation Responses Made
Control Group (CL-1) (N=11)	88	7
Multiple Schedule Group (IR-2) (N=11)	88	82
Continuous Reinforce. Group (CR-3) (N=11)	88	82

TABLE VII

RESULTS OF THE POSTTEST GIVEN FOUR WEEKS AFTER TRAINING CEASED (PT2) INDICATING CONSERVERS AND NON-CONSERVERS

Subjects	Ss Conserving on All PT2 Items with all Symbolic Explanations (Conservers)	Ss Failing to Conserve on one or more items on PT2 (Non-conservers)
Control Group (CL-1) (N=11)	0	11
Mult. Sched. Group (IR-2) (N=11)	10	1
Continu. Rein. Group (CR-3) (N=11)	10	1

of the 8 items on PT-2 and thereby became qualified to be designated as conservers. The absence of any difference between the performances of the training groups on PT-2 undermines hypothesis three (H_3) which predicted that there would be a significant difference in favor of the IR-2 group of PT-2.

Hypothesis four (H_4) predicted IR-2 Ss would exhibit the conservation of substance operation significantly more often than CL-1 Ss as demonstrated at PT-2. The data in Tables VI and VII suggests support for the prediction of hypothesis four. Thus, Table VI indicates that while CL-1 Ss responded correctly on seven of 88 opportunities, IR-2 Ss, like CR-3 Ss, conserved on 82 of the same 88 trials. In addition, the data presented in Table VII lends more direct support to H_4 since Table VII presents not only the number of correct responses; it also presents the number of Ss who satisfied all the criteria for asserting the presence of the conservation of substance operation. With 10 of the 11 Ss in IR-2 answering all 8 test questions correctly and presenting appropriate explainations for all answers given, and no CL-1 Ss so doing, the significant difference is very apparent ($P<.005$). Table VIII presents the significance levels for the comparisons of all three group performances on PT-2.

Hypothesis five (H_5) predicted that PT-2 would reveal no significant difference between groups CL-1 and CR-3 with respect to the number of Ss in each group exhibiting the presence of the conservation operation at PT-2. The data

TABLE VIII

POSTTEST TWO (PT-2) RESULTS OF TREATMENT GROUPS (IR-2, CR-3) COMPARED TO A CONTROL GROUP (CL-1) USING FISHER'S EXACT Z

	-	+
CL-1	11	0
IR-2	1	10

(One tailed Test)
$P < .005$
(Two tailed test)
$\alpha < .01$

	-	+
CL-1	11	0
CR-3	1	10

(One tailed test
$P < .005$
(Two tailed test
$\alpha < .01$

	-	+
IR-2	1	10
CR-3	1	10

(One tailed test
$P > .05$
(Two tailed test)
$\alpha > .01$

presented in Tables VI, VII, and VIII do not support the prediction of H_5. While 10 of the 11 Ss in CR-3 display the conservation of substance operation at PT-2, not one of the 11 Ss in CL-1 exhibit conservation of the same test. The difference is significant ($P < .005$).

CHAPTER VI

DISCUSSION

Summary of Experimental Findings

The present study examined two basic questions: (a) Can Ss below the age at which the "natural" acquisition of conservation of substance usually occurs, be accelerated in their acquisition of this operation through shaping procedures? (b) Does the pattern of reinforcement applied during training, affect the durability, or resistance to extinction of the trained behavior?

These questions were examined in terms of the results of a controlled experiment. In addition to the use of pretests, control was provided by the inclusion of a no-training group along with two groups which were trained in an identical manner excepting for the schedules of reinforcement employed. Statistical controls relating to a number of factors of significance in ontogenetic development (Lefrançois, 1966), namely age, S.E.S. and M.A., were examined for each of the three groups which were formed by randomly assigning Ss to them. Since the three groups were found not to differ significantly on these variables, Ss' posttest performance was assumed to be free of bias arising from between-group differences in age, S.E.S. and M.A..

The posttest data indicated that the training procedure, which incorporated apparatus and a task sequence, embodying the principle of selective reinforcement on successive approximations (shaping), was singularly effective

in accelerating the acquisition of the conservation of substance operation. Twenty Ss out of the 22 Ss who were trained, acquired the conservation operation while no control Ss did so. Half (10) of the Ss who acquired conservation were reinforced for every correct response made during training, while the other 10 Ss who met the conservation criteria were reinforced for correct responses according to multiple schedules. There was no significant difference between the trained groups with respect to conservation acquisition and resistance to extinction. Thus the hypothesis that Ss who were reinforced intermittently would, after a prolonged period of time, maintain the conservation behavior more often than Ss reinforced on a continuous schedule, was rejected. Apparently both treatment conditions produce reliable, generalized and durable conservation behavior equally well.

Some phenomena associated with the two Ss, one in each of the training conditions, who failed to meet the conservation criteria, may be worth noting. The IR-2 S met the criteria on PT-1 but failed to do so on PT-2. On PT-2 the IR-2 S gave all correct responses to the deformations but stopped giving explainations after the second PT-2 item. All her explainations, up to that point, were of the symbolic-logical type. When E persisted in his attempts to elicit explainations for the remaining items, S, on each occasion said, "They just are," and proceeded to talk about something else. The non-conserver in CR-3 did not meet the conservation criteria on either posttest. However,

it is interesting to note that after training and testing were completed, E discovered that this non-conserving CR-3 S was allergic to candies which were used, during training, as reinforcement objects. Furthermore, E had observed that this CR-3 S appeared reluctant to answer questions, and gazed around the room during most of the time she was with E while training and testing. It was discovered later, that between training sessions S's mother had repeatedly told her to avoid the reinforcers (candy).

Interpretation and Implications

Since the overall results of the experiment were mainly as hypothesized, any detailed interpretation of the outcomes would amount to little more than a repetition of the theory and postulates from which the hypotheses were derived. However, there are certain points, arising from a consideration of the results of the present study, which may be noteworthy. Furthermore, directions for further study may be provided by some questions which arise from the present study.

The most noteworthy results are(a) that the application of the Skinnerian principles of selective reinforcement and successive approximations appears to be effective in inducing the conservation of substance operation, and(b) the application of reinforcement on an intermittent schedule does not appear to be a necessary prerequisite for conservation durability. However, Staats et al (1964) have suggested that "there

appears to be an interaction between the components of a multiple schedule ..." and "...this is a limiting factor in generalizing the effects of a component in a multiple schedule to its effects in isolation (ibid p. 147)." These considerations suggest a need for more research on schedules of reinforcement and their effects on human subjects. This need is particularly acute with respect to complex human behavior, such as the acquisition of conservation operations, since the focus of the great bulk of research on reinforcement schedules with humans has been on simple responses such as button pushing. Why the conservation behaviors of CR-3 Ss did not extinguish, like other simpler behaviors do when the continuous schedule with which they were produced is discontinued, is only one of a number of questions which might be answered through such research.

Another obvious implication for research, arising from the current results, has to do with replications of this study and applications of the procedures utilized (or refinements thereof) to acceleration studies on other conservations.

In addition, further studies such as that suggested by Watson (1968), with respect to the gaining of a more precise understanding of the possible role played by discriminative stimuli in conservation acquisition, seem warranted. The procedures and results of the present study appear to support Watson's suggestion that the conservation response may result from the reinforcement of certain

attentional behaviors (ibid). Thus, the explainations given by trained Ss in the present study, while congruent with the definitions of symbolic and symbolic-logical explainations could, as Watson suggests (ibid. p. 452), be interpreted as reports of Ss' identification of discriminative stimuli. For example, the explaination that the quantities of two objects remain the same (or remain different) after a deformation "because nothing was added or taken away" can be interpreted as a report by S that since a certain set of stimuli were present in the transformational action and others (adding or taking away behavior) were absent, no change in amount resulted therefrom. Accordingly, further studies might profitably incorporate the systematic arrangement of stimuli and selective reinforcement procedures for shaping complex behavior. In so doing, a focus on the role of discrimination learning as it relates to behavior acquisition may uncover more about the role of discriminative stimuli in the acquisition of complex human behavior such as concrete operations.

If, as Piaget has contended (Marmelstein et al, 1967), the child's interaction with his environment produces developmental changes such as the acquisition of the conservations, there is some probability that there are elements in that environment which are irrelevant to those developmental events and other elements which are functionally related to them. If this proposition is correct two other notions arising therefrom might be considered. The first is

that the environmental elements which are functionally relevant to the production of developmental events are very likely not systematically encountered by the child. As a consequence, the time that elapses before their functional effects are observable may be considerably more than it otherwise has to be. That is, the development that is occasioned by the child's interaction with the functional environmental elements, may be, in terms of time, inefficiently produced. The second notion is derived in part, from the first. If it can be discovered which environmental elements encountered by the child, produce developmental changes in him, then these elements might be systematically incorporated into a training program. The childs interaction with these environmental elements in the training program might well be far more efficient in producing the developmental change than the unsystematized interaction he would have with them, in those "natural" encounters with his "total" environment spoken of so glowingly by Piaget (1965, 1967).

Surely similar assumptions and propositions underly all attempts to educate or teach. Most certainly, they were implicit in the present study. The apparatus, task sequence, reinforcement and systematic changes in stimuli presentations were designed to present the child with phenomena which embodied elements from the environment. These were the elements which E hypothesized as those that the child must interact with if the developmental change involving conservation acquisition is to occur.

The results seem to indicate that children do not have to interact with their total environment in order for specific developmental changes to take place. The training experience apparently produced changes which met all of the criteria for the assertion of the presence of the conservation operation. It would appear that the difference between those Ss who acquired the operation through training and those who acquired it without specific training, is that the trained Ss acquired conservation through a more systematic, and therefore, efficient means and at a younger age.

Accordingly, the results of the present study suggest that it may well be possible to discover and isolate those salient elements of the child's environment which when interacted with, produce developmental change. Furthermore, the incorporation of these critical elements in training programs may result in development, such as the acquisition of conservation, for which one would otherwise have to wait.

The implications of these suggestions might well be considered by those who teach young children. For example, a child's lack of "readiness" to learn certain numerical or arithmetic concepts might now be subject to remediation since the presence of conservation of substance has been suggested (Mermelstein et al, 1967) as a necessary precursor to the learning of some numerical concepts. Furthermore, the present study may have other implications for answers to the questions about when to teach what to whom and how since the pace of a child's development may be subject to manipulation.

A Note on Theory

Conservation behaviors, like most behavioral phenomena present the possibility of multiple interpretations. The number of different approaches to acceleration studies deomonstrate this more than adequately. While some of these approaches are irreconcilable, others appear to be quite compatible and even complementary. The results of the present study appear to indicate that S-R explainations of the developmental phenomena of conservation are not incompatible with Piaget's theory. The following example might serve as a point of departure for further explorations of theory.

It is generally accepted that the assimilation, accommodation proccesses, which are the mechanisms of change or development in the Piagetian framework, produce changes in schema as a result of the organism's encounter with aliment of an optimal magnitude. The S-R successive approximations, or shaping, process incorporates the provision of small increments and decrements, in sequence, of stimulus patterns as a mechanism for behavioral change or development. The two approaches appear to have much in common. That is, the provision of small increments and decrements in the sequence of stimulus patterns presented in training, might have been described as the systematic presentation of optimal aliment (Baldwin, 1967) which activated assimiliation-accommodation processes and by so doing increased the child's adaptability by providing him with new behavioral schemas.

which would be activated by the subsequent encounter with similar phenomena.

Further explorations of Piagetian theory and concepts in terms of learning principles may produce new and more useful concepts, research ideas and methods, and new understanding of developmental phenomena which may well be applicable to teaching.

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APPENDIX A

(a) APPARATUS:

(i)

CONTAINER	INNER DIAMETER(INCHES)	HEIGHT(INCHES)	NUMBER OF ITEMS
A	7/8	3	4
B	1	2 7/8	4
C	1 1/4	2 11/16	4
D	1 1/2	2 5/8	4
E	1 3/4	2 1/2	4
F	2	2 3/8	4

(ii) One electrical candy dispenser with transformer and switch.

(iii) Supply of "Smarties" (candy).

(Iv) Four containers of colored water: red, yellow, blue, green.

(v) Testing beakers

(vi) Plasticine

(b) ORIENTATION:

Each S was shown the candy dispensing apparatus and encouraged to manipulate it. Following the manipulation of the machine by S, E said "Now we are going to play with some things and I am going to ask you what you think about some of them - you will have to watch very carefully. When you answer some questions we will operate the Smarties machine and you will get some Smarties. Now, don't forget that you must watch very carefully and remember what we begin with each time."

(c) STANDARD QUESTION:

After each transfer E asks S, "Do you think the ___________ has the same amount of juice, more juice or less juice than ________?" The order of the phrases referring to amount was randomized.

APPENDIX B

LIST OF ITEMS IN THE TRAINING SESSION:

The letters A to F inclusive, represent a series of transparent containers which vary in height and diameter. A, the tallest, has the smallest diameter, while F, the shortest, has the greatest diameter. Each of the containers possesses a progressively larger diameter and a smaller height than the container represented by the letter immediately prceding it. Thus, C has a greater height than D but a smaller diameter than D, while D has a greater height than E but a smaller diameter than E. A description of beakers, is found in part (a) of Appendix A.

Symbols, like "F_2 - A_1" represent a transfer of the contents of the first container to the second, for example from F_2 to A_1. Colors are descriptive of substance appearance and "same" or "different" represent the appropriate answers for each stimulus situation. The appropriate response given, indicates whether the initial elements possessed equivalence and identity.

The following sequence of deformations were encountered by each experimental S. The training took place over 16 days. Each S had four training sessions with an average of four days intervening between sessions. The individual training sessions are labeled as phase 1, 2, 3, and 4 respectively.

DAY TWO: PHASE 1. TRAINING

	INITIAL CONTAINERS	TRANSFER	COLOR	APPROPRIATE RESPONSE
1.	F_1F_2	F_2 - F_3	red	same
2.	F_1F_2	F_2 - F_3	red	different
3.	A_1A_2	A_2 - A_3	blue	different
4.	A_1A_2	A_2- A_3	blue	same
5.	B_1B_2	B_2- B_3	yellow	same
6.	B_1B_2	B_2- B_3	yellow	different
7.	C_1C_2	C_2- C_3	green	different
8.	C_1C_2	C_2- C_3	green	same
9.	D_1D_2	D_2- D_3	red	same
10.	D_1D_2	D_2- D_3	red	different
11.	E_1E_2	E_2- E_3	blue	different
12.	E_1E_2	E_2- E_3	blue	same
13.	A_1A_2	A_2- A_3	blue	same
14.	A_1A_2	A_2- A_3	blue	different
15.	A_1A_2	A_2- B_1	blue	same
16.	A_1A_2	A_2- B_1	blue	different
17.	B_1B_2	B_2- B_3	yellow	different
18.	B_1B_2	B_2- B_3	yellow	same
19.	B_1B_2	B_2- A_1	yellow	same
20.	B_1B_2	B_2- A_1	yellow	different
21.	B_1B_2	B_2- B_3	green	different
22.	B_1B_2	B_2- B_3	green	same
23.	B_1B_2	B_2- C_1	green	same
24.	B_1B_2	B_2- C_1	green	different
25.	A_1A_2	A_2- B_1	blue	same
26.	A_1A_2	A_2- A_3	blue	different

DAY SEVEN: PHASE 2. TRAINING

	INITIAL CONTAINERS	TRANSFER	COLOR	APPROPRIATE RESPONSE
1.	C_1C_2	C_2- C_3	green	different
2.	C1C2	C2- C3	green	same
3.	C_1C 2	C_2- B_1	green	same
4.	C_1C_2	C_2- B_1	green	different
5.	C_1C_2	C_2- A_1	red	same
6.	C_1C_2	C_2- A_1	red	different
7.	C_1C_2	C_2- D_1	yellow	same
8.	C_1C_2	C_2- D_1	yellow	different
9.	C_1C_2	C_2- E_1	blue	different
10.	C_1C_2	C_2- E_1	blue	same
11.	C_1C_2	C_2- F_1	blue	same
12.	C_1C_2	C_2- F_1	blue	different
13.	D_1D_2	D_2- D_3	red	same
14.	D_1D_2	D_2- D_3	red	different
15.	D_1D_2	D_2- C_1	red	same
16.	D_1D_2	D_2- C_1	red	different
17.	D_1D_2	D_2- B_1	green	same
18.	D_1D_2	D_2- B_1	green	different
19.	D_1D_2	D_2- A_1	yellow	same
20.	D_1D_2	D_2- E_1	yellow	same
21.	D_1D_2	D_2- F_1	yellow	same
22.	D_1D_2	D_2- F_1	yellow	different
23.	D_1D_2	D_2- A_1	blue	different
24.	D_1D_2	D_2- A_1	blue	same

DAY TWELVE: PHASE 3. TRAINING

	INITIAL CONTAINERS	TRANSFER	COLOR	APPROPRIATE RESPONSE
1.	D_1D_2	$D_2 - D_3$	red	same
2.	D_1D_2	$D_2 - D_3$	red	different
3.	A_1A_2	$A_2 - B_1$	blue	same
4.	A_1A_2	$A_2 - C_1$	blue	same
5.	A_1A_2	$A_2 - D_1$	blue	same
6.	A_1A_2	$A_2 - D_1$	blue	different
7.	B_1B_2	$B_2 - E_1$	red	same
8.	E_1E_2	$E_2 - E_3$	blue	same
9.	E_1E_2	$E_2 - E_3$	blue	different
10.	E_1E_2	$E_2 - F_1$	blue	same
11.	E_1E_2	$E_2 - F_1$	blue	different
12.	E_1E_2	$E_2 - D_1$	yellow	different
13.	E_1E_2	$E_2 - D_1$	yellow	same
14.	E_1E_2	$E_2 - C_1$	yellow	same
15.	E_1E_2	$E_2 - C_1$	yellow	different
16.	E_1E_2	$E_2 - B_1$	yellow	same
17.	E_1E_2	$E_2 - A_1$	yellow	same
18.	F_1F_2	$F_2 - F_3$	green	different
19.	F_1F_2	$F_2 - E_1$	green	different
20.	F_1F_2	$F_2 - E_1$	green	same
21.	F_1F_2	$F_2 - D_1$	green	same
22.	F_1F_2	$F_2 - C_1$	green	different
23.	F_1F_2	$F_2 - B_1$	green	same
24.	F_1F_2	$F_2 - A_1$	green	same

DAY SEVENTEEN: PHASE 4. TRAINING

	INITIAL CONTAINERS	TRANSFER	COLOR	APPROPRIATE RESPONSE
1.	F_1F_2	F_2- F_3	green	different
2.	F_1F_2	F_2- F_3	green	same
3.	F_1F_2	F_2- E_1	red	same
4.	F_1F_2	F_2- E_1	red	different
5.	F_1F_2	F_2- D_1	red	same
6.	F_1F_2	F_2- D_1	red	different
7.	F_1F_2	F_2- C_1	yellow	same
8.	F_1F_2	F_2- B_1	yellow	same
9.	F_1F_2	F_2- B_1	yellow	different
10.	F_1F_2	F_2- A_1	yellow	same
11.	A_1A_2	A_2- F_1	blue	same
12.	A_1A_2	A_2- F_1F_2	blue	same
13.	F_1F_2	F_2- A_1A_2	red	same
14.	F_1F_2	F_2- A_1A_2	red	different
15.	F_1F_2	F_2- $A_1A_2A_3$	red	same
16.	A_1A_2	A_2- $F_1F_2F_3$	green	same
17.	B_1B_2	B_2- F_1	green	same
18.	B_1B_2	B_2- F_1	green	different
19.	B_1B_2	B_2- A_1A_2	yellow	different
20.	B_1B_2	B_2- $A_1A_2A_3$	yellow	same
21.	B_1B_2	B_2- F_1F_2	yellow	same
22.	D_1D_2	D_2- A_1F_1	red	same
23.	F_1F_2	F_2- A_1	blue	same
24.	F_1F_2	F_2- $A_1A_2A_3A_4$	blue	same

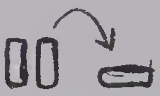
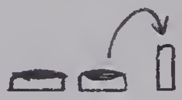
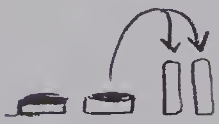
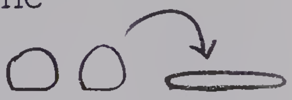
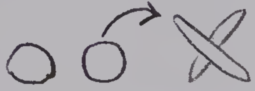
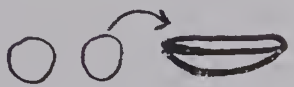
APPENDIX C

Group: ____________________ (code)

1. Control
2. Intermittent
3. Continuous

NAME ____________________ FATHER'S OCCUP. (BLISHEN) ________

AGE (CR. IN MO.) ________ SEX (M OR F) ______ HARRIS GOODENOUGH SCORE __________

POSTTEST I	Items:	Response	Explain:
Liquid		S	
		d	
		S	
Plasticine		S	
		S	
		S	

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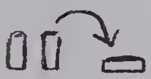
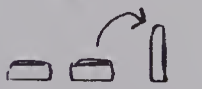
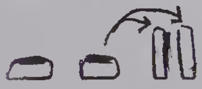
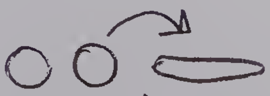
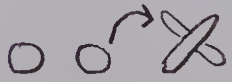
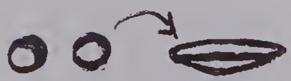
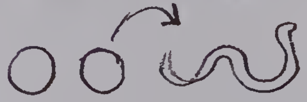
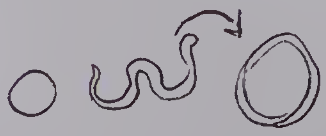
Liquid		S	
		d	
		S	
Plasticine		S	
		S	
		S	
		S	
		S	

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